Overview: Business Feasibility of the TAMDAR System

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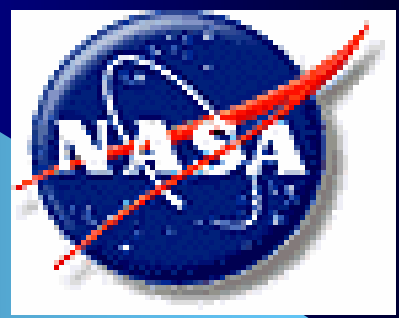


Department of Engineering Management

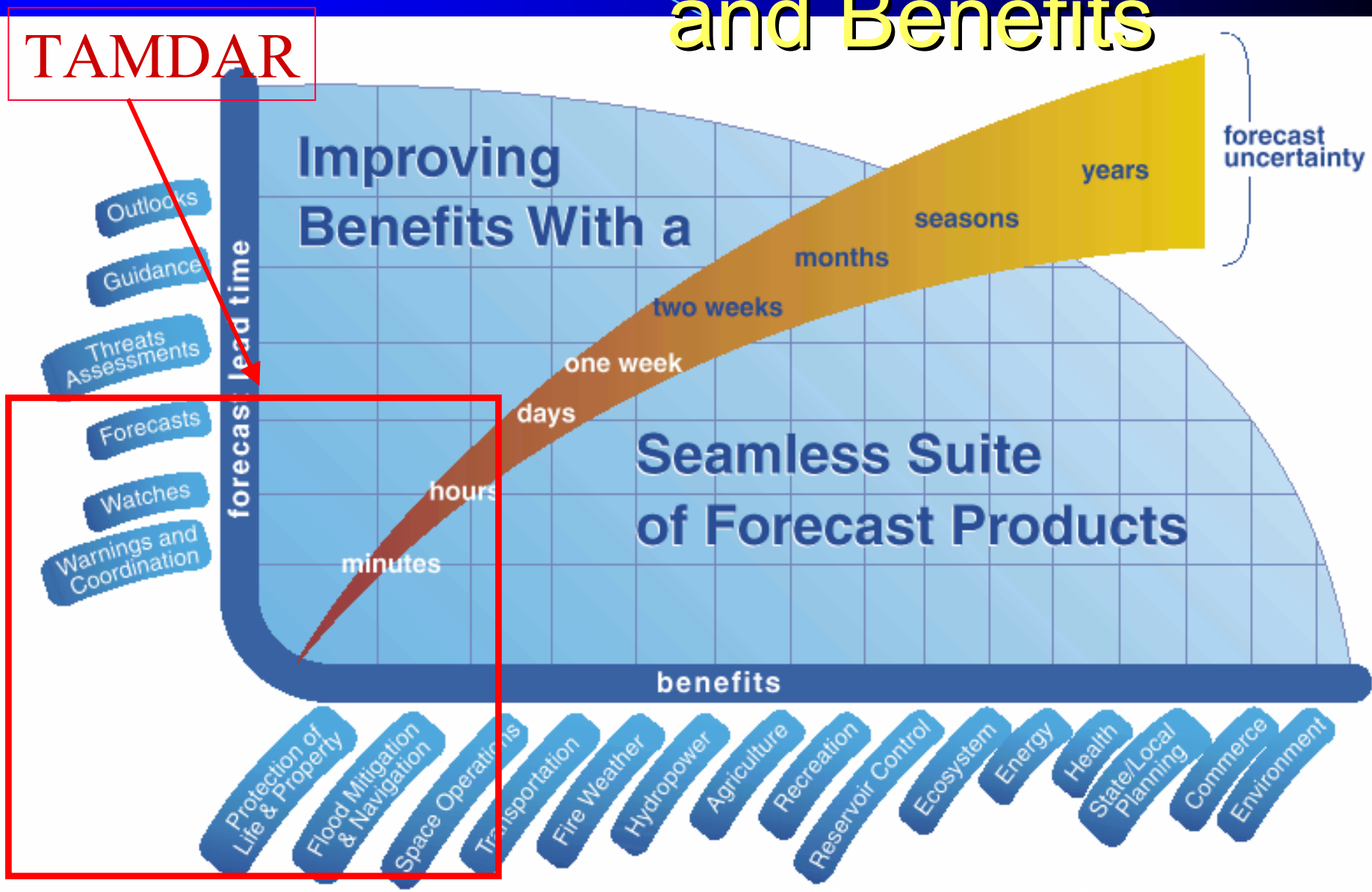
Agenda- Current Status

- Introduction: Study Objectives and System Description
- General Aviation Market Analysis
- Carrier Market Analysis
  - Commuter, business, package
- Competitive Weather Source Analysis
- Weather Information Providers
- Policy Issues and Implications
- Conclusions

What is TAMDAR?

- Tropospheric Airborne Meteorological Data Reporting
  - Past reincarnations: EPIREPS, AUTOMET
- Components: sensor package, signal processors, and communications equipment
  - Operational Concept: Carried aloft by participating aircraft to report weather conditions to ground-based receiving stations for distribution into a national system.

Forecast Lead Time and Benefits



Sensor Package: General Concept

- GPS location
- Indicated Airspeed
- Pressure Altitude
- Temperature
- Relative Humidity
- Magnetic Heading
- Winds aloft (direction & speed)
- Accelerometer (Turbulence)
- Ice detection and warning

Target price of one manufacturer: $5,000

Market target: 2003

TAMDAR Study Questions

- Most likely installation scenarios:
  - Cost of installation and operation of sensor
  - Adoption motivation / policy issues
  - Cost of alternate weather information sources
  - Potential for new weather products
  - Societal / aviation benefits
- Key: Develop an integrated business case.

Integrated Team Approach

Forgive me if I left anyone out!

Communication Link

Package Carriers

AOPA

Commercial Carriers

Commuter airlines

GA

Weather Service

ATA

Weather Information Providers

GA Survey Overview

- Focus: Explore issues related to GA involvement and motivation to participate
- New aircraft equipment
  - Study of 40 models and weather equipment
- In service equipment
  - Oshkosh survey (141 participants)
  - AOPA web survey (138 participants)

New Aircraft Weather Equipment

- Examined standard weather information equipment on 40 models of new aircraft.

With weather instruments	47.5%
Models with weather radar	17.5%
Models with stormscope	27.5%
Without weather instruments	52.5%

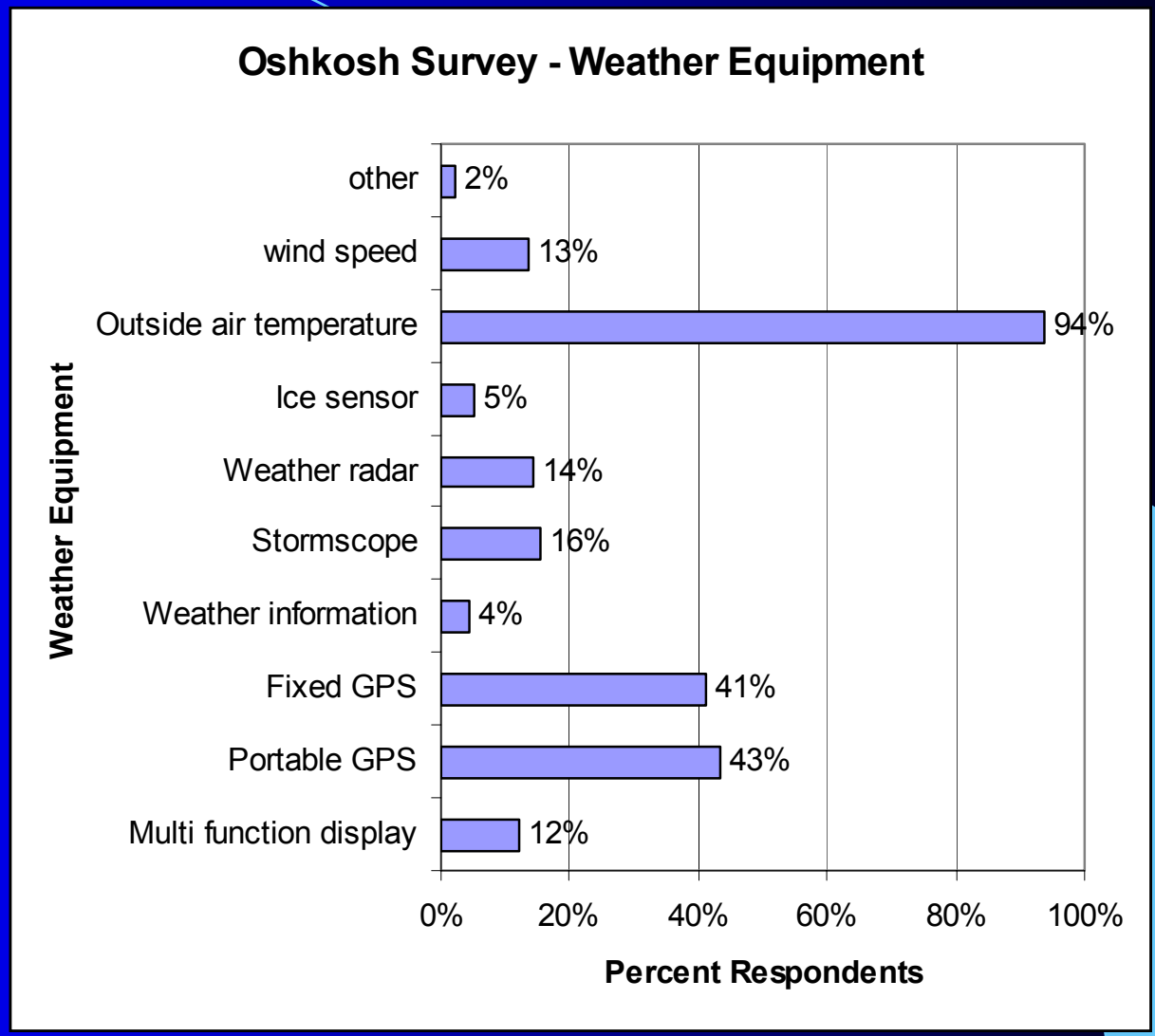
- Conclusion: opportunity to offer weather information even to new aircraft owners as incentive to participate.

Oshkosh / AOPA Surveys

- To determine motivations of current GA owners, two surveys were conducted. Goals included:
  - Identify weather related equipment
  - Assess importance of cockpit weather information
  - Determine incentive priority
- Oshkosh shown -Very similar results for AOPA.

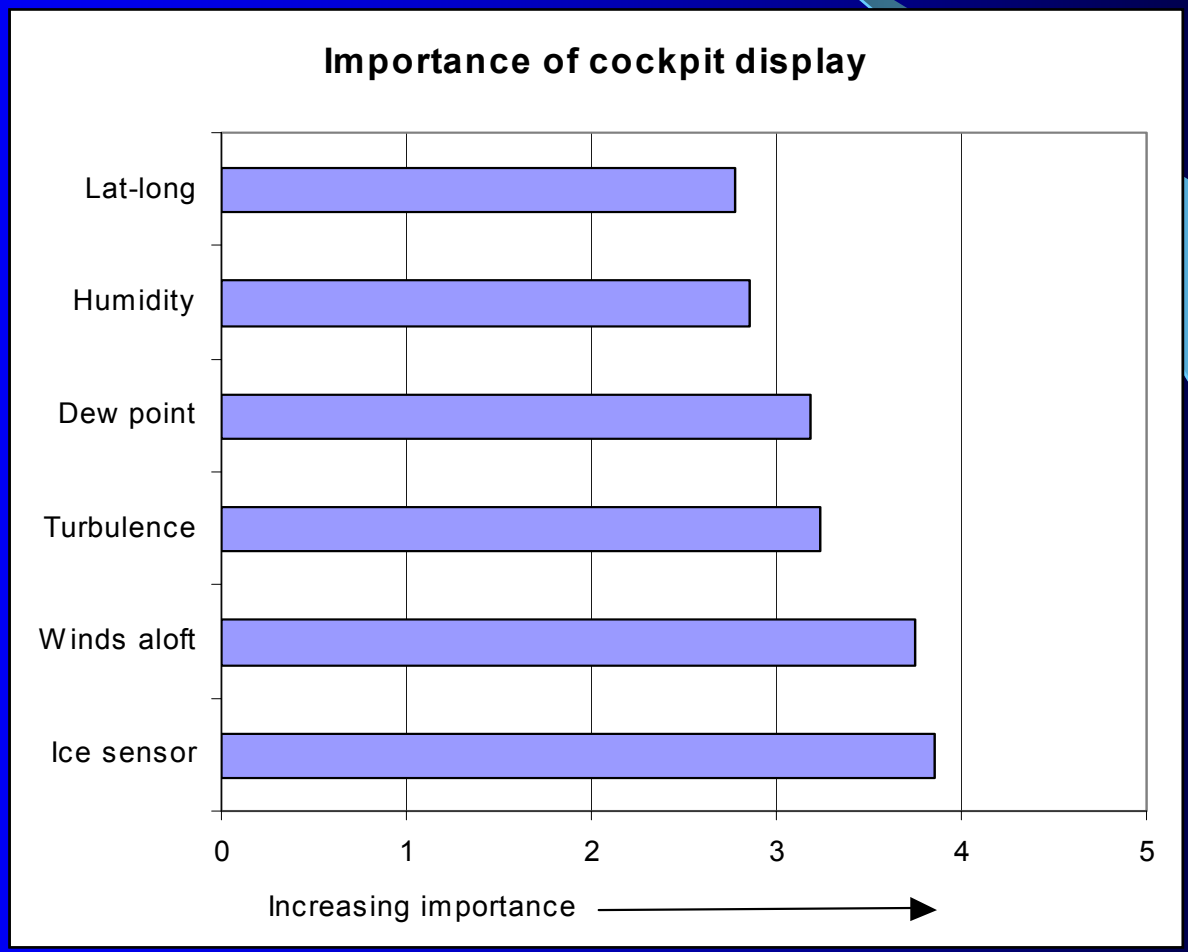
Weather Related Equipment

- 75% below 18,000 ft.
- 89% single or multi engine piston
- 79% less than 20 hours per month



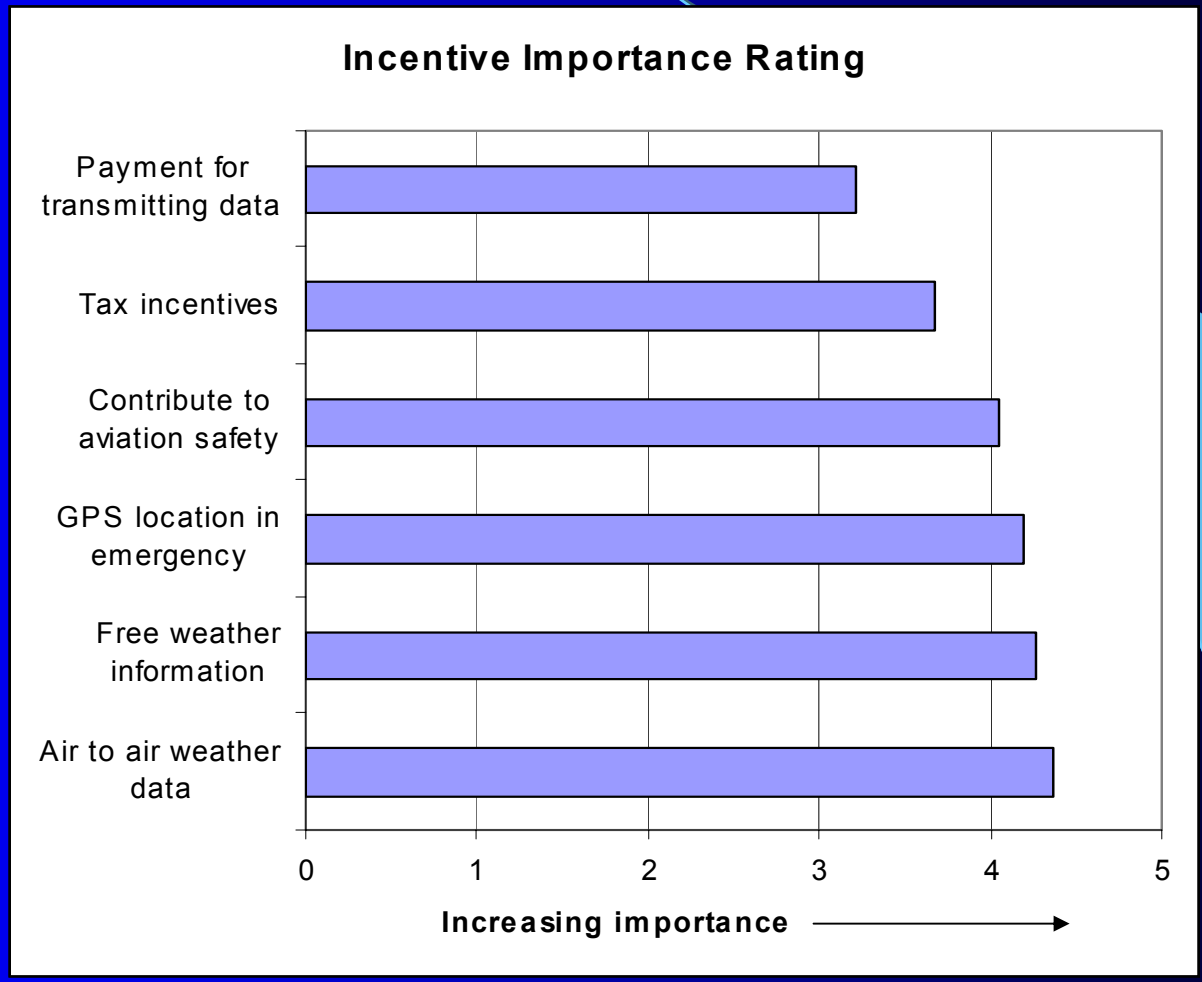
Cockpit Weather Data

Rate importance if you could select TAMDAR data for display in the cockpit (1-5very important):



TAMDAR Incentive

Rate importance of these incentives for those who install TAMDAR.

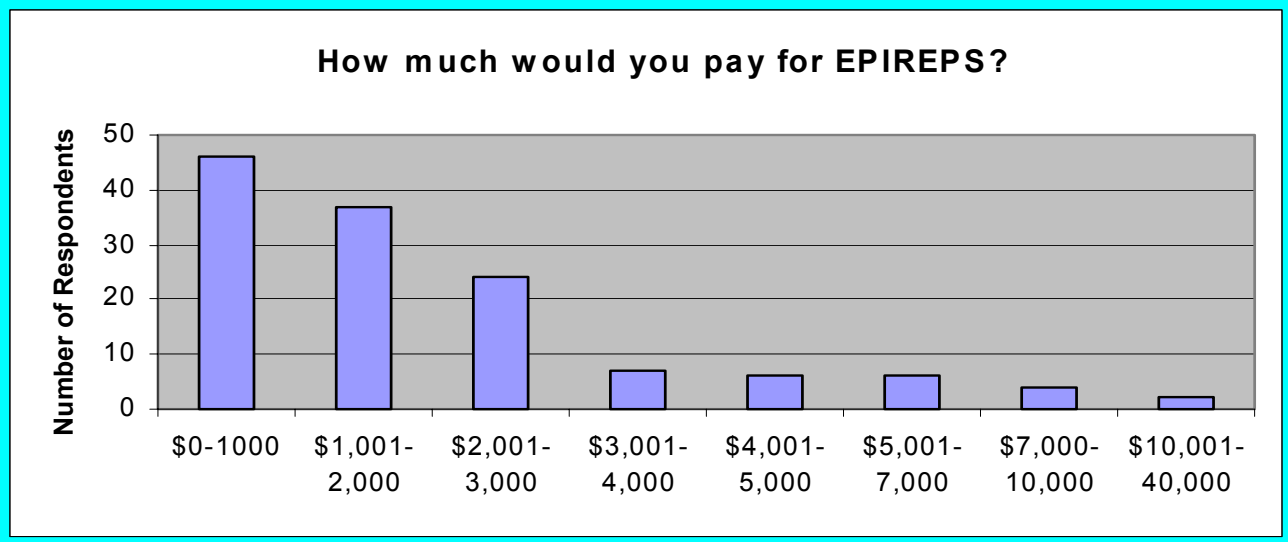


Oshkosh-Willingness to Pay

- For weather data items rated 4 or 5:

Price		%
$0-1000	46	34.8
$1,001-2,000	37	28.0
$2,001-3,000	24	18.1
$3,001-4,000	7	5.3
$4,001-5,000	6	4.5
$5,001-7,000	6	4.5
$7,000-10,000	4	3.0
$10,001-40,000	2	1.5

Non recurring cost that Participants are willing to pay for weather data rated 4 or 5.



Summary - GA Analysis

- Owners motivated for weather information
  - Opportunity for new aircraft and current fleet
- Low cost threshold for instrument purchase plus data link costs
- Operational issues
  - Data quality, instrument repair
  - Consistency of data input and transmission format
  - System management and control

Data Link Issue

- In GA study, it was clear that the main cost factor was the recurring and non recurring cost of the data link.

Conclusion: Examine market segments that may already (or soon will) have data link systems

  - Focus: Regional airlines, business, package carriers

Current ACARS Status

- Estimates of current fleet
  - 6500 aircraft currently ACARS equipped
  - 1500 are high end GA
- Current message cost (hesitation!):
  - Automet message with identifier data: 103 characters
  - Typical transmission costs $0.07-$0.08 per kilo character (1000 characters)
  - For one data point ≈ $0.01
  - Commonly quoted ranges $0.04 to $0.10 appear high.

Current Market Analysis

- Current surveys under way to analyze:
  - Regional airlines, package carriers, business operators
- Areas of interest:
  - Current Fleet characteristics and changes in next five years (issue of regional jets)
  - Typical flight characteristics
  - Current fleet management / communications equipment
  - Motivations to participate

Regional Carrier Responses

- Typical fleet transition:
  - Large regional carrier currently has 68 turboprop and 46 jets- none with GPS or ACARS/ AFIS
  - In five years, estimates 160 jets and 19 turboprop- all with GPS and ACARS / AFIS
- Flight characteristics:
  - 8 flights per day
  - Average distance is 160 for props, 360 for jets

Fleet Management / Communication

- As noted, many aircraft are not equipped with GPS and / or ACARS / AFIS (airborne flight information system).
- Transition discussed with change to jets.
- High priorities for change include:
  - Cost reduction (automate OOOI data- out, off, on, in)
  - ATC communications (e.g. pre departure clearance)
  - Future services (free flight requirement, ADSB, etc.)

Typical Recent Business Case

- Large commuter airline decided to install flight management system in regional jet fleet:
  - Total installed cost was $35,000 for communications and interface equipment
  - Net monthly deficit per tail in “hard cost saving” was $350.
  - Justified as worthwhile by better access to ATC

Weather Information Providers

- Survey of viewpoint of weather information providers (for profit):
  - Goal: Is there commercial potential in TAMDAR?
- Packaged data set: Aviation, DOTS, military
- Improved forecast products: Above + broadcast
- Several comments focus on cost effective selection of data points.

Competitive Weather Sources

- TAMDAR complements other weather data
  - Provides opportunity for data correlation (e.g. satellites).
- However there is an issue of cost saving in other data gathering areas and cost effectiveness.
- Example: Weather balloons gather data for many purposes. Could the number be reduced?

Canadian AMDAR Case

- Weather balloon replacement considerations in Canada:
  - Cost of AMDAR flight: 30 observations @$0.04 each = $1.20 (VHF transmission- satellite higher)
  - Annual cost = 365*$1.20
  - Annual cost of a weather balloon launching is over $300
- Is a daily AMDAR flight worth more than a balloon launch? Is this a trade off that is appropriate in some cases or many cases?

Cost Summary- Estimates

- Sensor Suite: Target- $3500-$6500 including installation
- Communication system: $10,000-$35,000
  - Prefer to build on existing or planned flight information systems (e.g. ACARS)
- Data link costs: $0.01 per data point

How to Structure the Business Case?

- Program is aviation focused but societal benefits.
- Current issues in NAS, crowding, delays, etc.
  - TAMDAR can improve this
- Conclusion: build base business case on aviation impact
- Issue: How far can this move us forward?

TAMDAR Forecast Impact

- TAMDAR should improve short term forecasts in the following areas:

  - Significant convection / severe weather
  - Cloud cover / ceiling / fog / visibility
  - Low level winds direction / shift
  - Low level temperature structure
  - High level winds, jets
  - Precipitation type (icing, snow, rain)
  - Maximum / minimum temperature
  - Turbulence and wind shear
  - Other: _____

Current survey areas under discussion.

TAMDAR Terminal Operation Impact

Quantify delays from:

- Convection or severe terminal area weather.
- Terminal cloud cover, ceiling, visibility or fog
- Anticipation of wind direction or wind shift in the terminal area.
- Icing and snow in the terminal area
- Terminal area turbulence and wind shear
- Weather activity in arrival paths or departure gates into or out of the terminal area
- General precipitation conditions in the terminal area
- At smaller airports due to “ripple” effect of delays at hubs.

TAMDAR Airline Operations Impact

- Costs from reduced flight time or fuel use from improved flight planning prior to take off.
- Costs from reduced fuel consumption due to improved flight rerouting en route.
- Costs related to carrying excessive fuel as a precaution for forecast inaccuracy.
- Costs related to diversion or hold decisions for aircraft in flight.
- Costs related to hold decisions for aircraft on the ground.
- Costs due to improved ground operations.
- Costs related to improved traffic flow management.

Policy Issues and Implications

- Also studying possible policy implications - objective measures needed:
  - ***Input measures*** (Incentive and operating cost of the TAMDAR system).
  - ***Output measures*** (the number of data points).
  - ***Outcome measures*** (the amount of improvement in weather aviation delay and operating costs).
  - ***Impact measures*** (the decrease of weather related aircraft accidents in which TAMDAR weather data played a significant role, the improvement of aviation efficiency which resulted from TAMDAR data, increase of quality and efficiency of product and services which are weather related).

The Policy Investment Role in TAMDAR Technology: Principles

- There will always be areas where public benefits … substantially exceed the returns that can be realized by private investment alone. Federal investment is essential in these areas. The President's Committee of Advisors on Science and Technology provides the following criteria for government investment in technology
- "Areas of national importance where the marketplace alone cannot justify a sufficient level of technology investment by private industry "
- "...Where the benefits are too widely spread for any one company to recover its investment at a profit... "

(President's Committee of Advisors on Science and Technology (PCAST) *Executive Office of the President's Committee of Advisors on Science and Technology, Washington, D.C. 20500, June 18, 1996)*:

Business Case Example

- Per FAA, direct operating cost of 89M delay minutes was $3B in 1999.
  - Weather is a causal factor in about 70% or $2.1B.
- Cost range-equipping 2000 TAMDAR aircraft (WORST CASE) :
  - Non recurring cost: $33M (as incentive, TAMDAR pays half of $20k / unit plus sensor).
  - Recurring cost: Two flights per day at $1 each*2000*365 =$1.5M (Optimization model: Erol Ozan dissertation focus)

Is TAMDAR Worthwhile?

- For a five year life at 7%, previous cost is:
  - PV= ($39M)
  - Uniform annual cost = ($9.5M) per year
- Based only on direct operating cost figure, we need a 0.45% reduction in direct delay related weather costs to pay for TAMDAR.
  - Does not include many other possible cost savings and societal benefits (passenger costs, indirect costs, etc.)

Conclusions -Next Steps

- TAMDAR appears to have great potential to impact forecasting and aviation operations
- Significant challenge to document the savings impact of TAMDAR
  - Working group: NWS and ATA
- Things we don't know are diminishing
- Many thanks to all who have helped us get this far!